Abstract

Diffuse optical tomography is a promising imaging modality that provides functional information of the soft biological tissues, with prime imaging applications including breast and brain tissue in-vivo. This modality uses near infrared light (600 nm - 900 nm) as the probing media, giving an advantage of being non-ionizing imaging modality.

The image reconstruction problem in diffuse optical tomography is typically posed as a least-squares problem that minimizes the difference between experimental and modeled data with respect to optical properties. This problem is non-linear and ill-posed, due to multiple scattering of the near infrared light in the biological tissues, leading to infinitely many possible solutions. The traditional methods employ a regularization term to constrain the solution space as well as stabilize the solution, with Tikhonov type regularization being the most popular one. The choice of this regularization parameter, also known as hyper parameter, dictates the reconstructed optical image quality and is typically chosen empirically or based on prior experience.

In this thesis, a simple back projection type image reconstruction algorithm is taken up, as they are known to provide computationally efficient solution compared to regularized solutions. In these algorithms, the hyper parameter becomes equivalent to filter factor and choice of which is typically dependent on the sampling interval used for acquiring data in each projection and the angle of projection. Determining these parameters for diffuse optical tomography is not so straightforward and requires usage of advanced computational models. In this thesis, a computationally efficient simplex *method based optimization scheme for automatically finding this filter factor is proposed and its performances is evaluated through numerical and experimental phantom data. As back projection type algorithms are approximations to traditional methods, the absolute quantitative accuracy of the reconstructed optical properties is poor. In scenarios, like dynamic imaging, where the emphasis is on recovering relative difference in the optical properties, these algorithms are effective in comparison to traditional methods, with an added advantage being highly computationally efficient.*

In the second part of this thesis, this hyper parameter choice for traditional Tikhonov type regularization is attempted with the help of Least-Squares QR-decompisition (LSQR) method. The established techniques that enable the automated choice of hyper parameters include Generalized Cross-Validation(GCV) and regularized Minimal Residual Method (MRM), where both of them come with higher overhead of computation time, making it prohibitive to be used in the real-time. The proposed LSQR algorithm uses bidiagonalization of the system matrix to result in less computational cost. The proposed LSQR-based algorithm for automated choice of hyper parameter is compared with MRM methods and is proven to be computationally optimal technique through numerical and experimental phantom cases.